24GHz mmWave Sensor Human Static Presence Module Lite

User Manual V1.5

Catalog

1. Overview

This document focuses on the use of the sensor, the issues that need to be paid attention to in each phase, to minimize the design cost and increase the stability of the product, and to improve the efficiency of the project completion.

From hardware circuit reference design, sensor antenna and housing layout requirements, how to distinguish interference and multi-functional standard UART protocol output. The sensor is a self-contained system.

This sensor is a self-contained space sensing sensor, which consists of RF antenna, sensor chip and high speed MCU. It can be equipped with a host computer or a host computer to flexibly output detection status and data, and meet several groups of GPIOs for user customization and development.

2. Working Principle
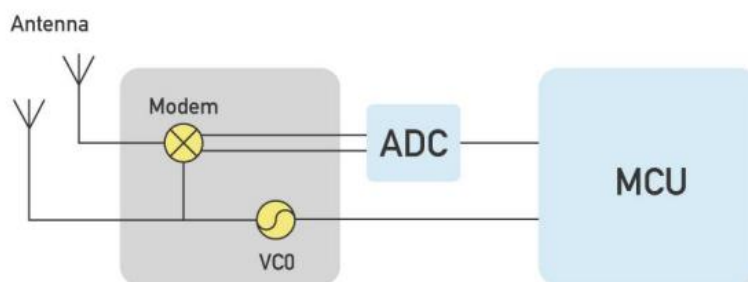
The sensor transmits a 24G band millimeter wave signal, and the target reflects the electromagnetic wave signal, and demodulates it from the transmitted signal. The signal is demodulated, then amplified, filtered, ADC and other processing to obtain the echo demodulation signal data. In the MCU unit, the amplitude, frequency and phase of the echo signal are decoded, and the target signal is finally decoded. The target parameters (body movement, etc.) are measured and evaluated in the MCU.

MR24HPC1 Human Static Presence Module Lite based on the mechanism of continuous frequency modulation wave. It senses the biological presence, respiration, slight

movement, and movement of human body, and continuously records the presence of human body. It makes real-time judgments and outputs changes in motion speed, distance, intensity, as well as changes in spatial micro-movement intensity and distance. It achieves a rich environment detection application through various functional parameters and is compatible with complex environment detection applications of various styles.

3. Hardware Design Considerations

The rated supply voltage of the radar needs to meet 4.9 - 6V, and the rated current needs to be 200mA or more input is required. The power supply is designed to have a ripple of ⩽ 100mv.

3.1 Power supply can refer to the following circuit design
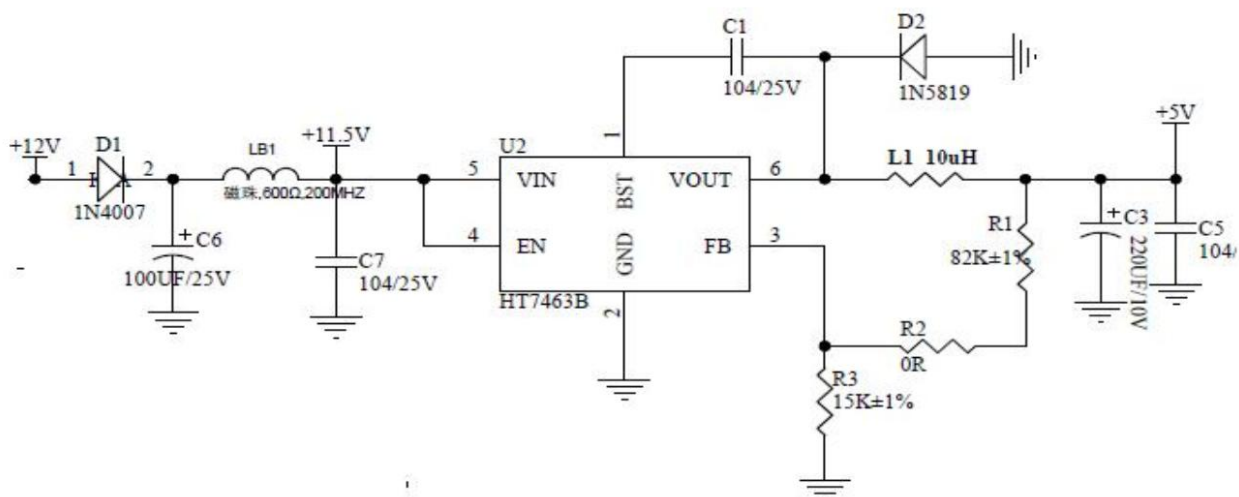
Figure 1

Figure 2

3.2 Wiring Diagram
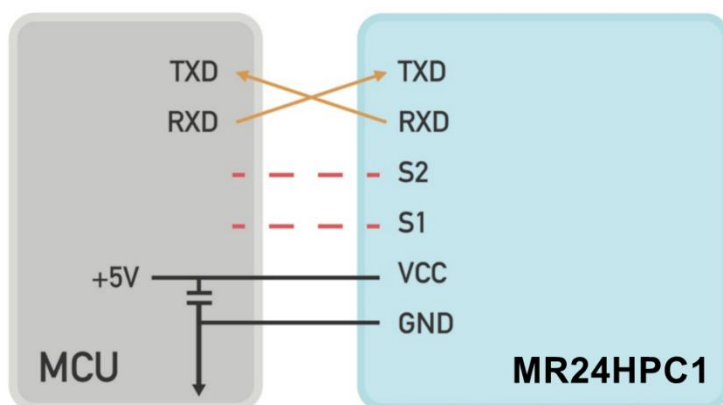
Figure 3 Module and peripheral wiring diagram

4. Antenna and housing layout requirements

PCBA: Need to keep the radar patch height $\geqslant$ 1mm higher than other devices

Housing structure: need to keep the radar antenna surface and the housing surface have 2 - 5mm distance

Housing detection surface: non-metallic housing, need to be straight to avoid bending surface, affect the performance of the whole sweep surface area Performance
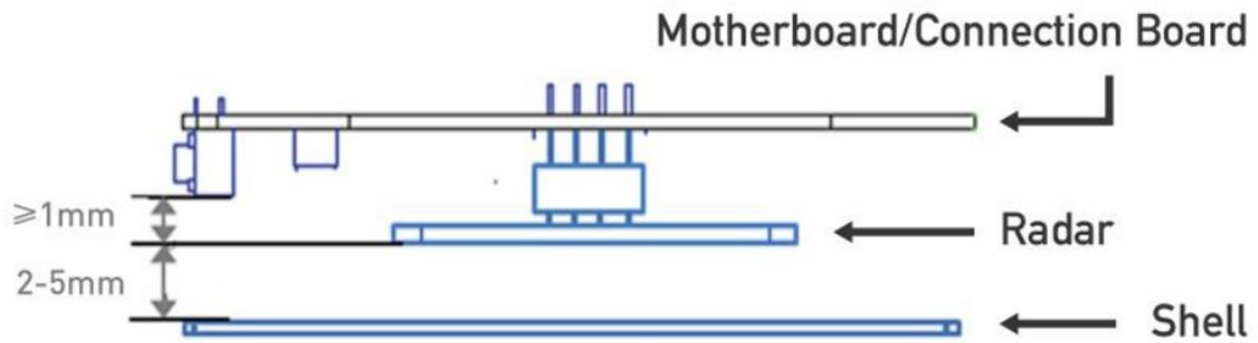
Figure 4

5. Electrostatic protection

Radar products with electrostatic sensitive circuitry inside, vulnerable to electrostatic hazards, so need to be in transport, storage, work and handling process to do a good job of electrostatic protection, do not touch the grasp of the radar hands. Therefore, it is necessary to do a good job in the transportation, storage, work and picking up process of static protection, do not touch and grab the radar module antenna surface and connector pins, only touch the corners. Do not touch the surface of the radar module antenna and connector pins with your hands, only touch the corners.

When handling the radar sensor, please wear anti-static gloves as much as possible.

6. Environmental interference analysis

6.1 In an unmanned state, sensors output results indicating the presence of a human being even though there is none.

In the normal state, the radar accurately detects the presence of a stationary human body or sleeping human body and outputs corresponding vital sign information. The reasons for this type of error could be:

A. The radar scans a large area and detects movements from outside the door or through a wooden wall nearby.

Adjustment method: Reduce the radar sensitivity or provide scene settings for the radar.

B. The radar is directly facing running equipment such as air conditioners or fans below.

Adjustment method: Adjust the position of the radar to avoid direct exposure to air conditioners or fans.

C. Object shaking caused by airflow from an air conditioner.

Adjustment method: Cotton and non-metallic items will not cause sensor false alarms, but metal items need to be fixed to avoid shaking.

D. The sensor is not fixed, which causes false alarms due to vibration.

Adjustment method: Avoid shaking or vibration by ensuring stable support.

E. Occasionally moving animals such as pets or birds.

Due to the radar measuring micro-movements with high sensitivity, it is difficult to eliminate this interference.

F. Power interference occasionally causing misjudgment.

Adjustment method: Try to maintain a stable power supply current.

6.2 When there is a person present, the sensor produces an incorrect output of no person detected.

The sensor detects the presence of a human body by sending and receiving electromagnetic waves, with higher accuracy the closer the person is to the radar.

A. The person is outside the range of the radar.

Solution: adjust the scanning range and installation angle of the radar. The measurement range of the radar varies in different environments due to differences in the electromagnetic wave reflection area, which may cause slight differences in the scanning area.

B. Metal obstruction causes incorrect output.

Obstruction by a thick desk, chair, or metal seat may block the electromagnetic waves and cause a misjudgment.

C. Differences in scanning angles.

The radar did not scan the torso, causing misjudgment.

D. The radar sensitivity is too low.

Solution: adjust the sensitivity parameter of the radar to increase sensitivity.

7. Protocol Description

This protocol is applied to the communication between the 24G millimeter wave Sensor Human Static Presence Module Lite and the host computer.

This protocol outlines the radar workflow, briefly introduces the interface protocol composition architecture, and The interface protocol structure is briefly introduced, and the related radar work requires control commands and data.

Interface level: TTL

Baud rate: 9600bps

Stop bit: 1

Data bits: 8

Parity check: None

7.1 Definition of frame structure

Frame header	Control word	Command word	Length identifier		Data	Checksum	End of frame
0x53 0x59	Control	Command	Lenth_H	Lenth_L	Data	Sum	0x54 0x43
2 Byte	1 Byte	1 Byte	1 Byte	1 Byte	n Byte	1 Byte	2 Byte

7.2 Description of the frame structure

a. Frame header: 2 Byte, fixed to 0x53,0x59;

b. Control word: 1 Byte

(0x01 - heartbeat packet identification, 0x02 - product information, 0x03 - UART upgrade, 0x05 - operation status, 0x80 - human presence)

c. Command word: 1 Byte (to identify the current data content)

d. Length identification: 2 Byte, equal to the specific byte length of the data

e. Data: n Byte, defined according to the actual function

f. Checksum: 1 Byte. (Calculation method of checksum: "frame header + control word + command word + length identifier + data" summed to the lower eight bits)

g. End of frame: 2Byte, fixed to 0x54,0x43;

8. Standard function (scene mode) description

This instruction mainly focuses on the detailed explanation and illustration of sensor standard functions such as scene mode, sensitivity, and unmanned time.

What needs to be explained is that the maximum detection range of the sensor for detecting human body in static and active states is different. Generally speaking, when the human body is in a static state, the maximum detection range of the sensor is smaller than that when the human body is in an active state.

Contents	Typical (default)	Maximum	Installation way
Human Active	5	5 m	side mount
Human Static	4	4 m	side mount
Human Sleep	3	3.5 m	side mount

The configurations of 8.2 to 8.4 are only effective in the standard mode (scene mode).

8.1 List of standard function data information

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
System Functions	Heartbeat Pack query	Send	0x53 0x59	0x01	0x01	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x01	0x01	0x00	0x01	0x0F	sum	0x54 0x43	
	Module Reset	Send	0x53 0x59	0x01	0x02	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x01	0x02	0x00	0x01	0x0F	sum	0x54 0x43	
Information Inquiry											
Product	Product Model	Send	0x53 0x59	0x02	0xA1	0x00	0x01	0x0F	sum	0x54 0x43	

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Information	query	Response	0x53 0x59	0x02	0xA1	0x00	len	len B Product Info	sum	0x54 0x43	
	Product ID query	Send	0x53 0x59	0x02	0xA2	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA2	0x00	len	len B Product ID	sum	0x54 0x43	
	Hardware Model query	Send	0x53 0x59	0x02	0xA3	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA3	0x00	len	len B Hardware model	sum	0x54 0x43	
	Firmware Version query	Send	0x53 0x59	0x02	0xA4	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA4	0x00	len	len B Firmware version	sum	0x54 0x43	The complete version number is obtained by converting the received hexadecimal number into a string.
Work status	Initialization completed information	Report	0x53 0x59	0x05	0x01	0x00	0x01	0x0F	sum	0x54 0x43	
Work status	Scene settings	Send	0x53 0x59	0x05	0x07	0x00	0x01	0x01~0x04	sum	0x54 0x43	1: Living Room 2: Bedroom 3: Bathroom 4: Area Detection
		Response	0x53 0x59	0x05	0x07	0x00	0x01	0x01~0x04	sum	0x54 0x43	Detection range for each scene mode: Living Room: 4m Bedroom: 3.5m Bathroom: 2.5m Area Detection: 3m (For related descriptions about the range of scene modes, please refer to section 8.2 of this document.)
	Sensitivity settings	Send	0x53 0x59	0x05	0x08	0x00	0x01	0x01~0x03	sum	0x54 0x43	1: Sensitivity level 1 2: Sensitivity level 2 3: Sensitivity level 3
		Response	0x53 0x59	0x05	0x08	0x00	0x01	0x01~0x03	sum	0x54 0x43	Detection range for each sensitivity level: Sensitivity level 1: 2m Sensitivity level 2: 3m

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
											Sensitivity level 3: 4m (For related descriptions about the range of sensitivity level, please refer to section 8.3 this document.)
	Initialization status inquiry	Send	0x53 0x59	0x05	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x05	0x81	0x00	0x01	0x01: Completed 0x02: Incomplete	sum	0x54 0x43	
	Scene settings inquiry	Send	0x53 0x59	0x05	0x87	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x05	0x87	0x00	0x01	0x00~0x04	sum	0x54 0x43	0: Scene mode not set 1: Living Room 2: Bedroom 3: Bathroom 4: Area Detection
	Sensitivity settings inquiry	Send	0x53 0x59	0x05	0x88	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x05	0x88	0x00	0x01	0x00~0x03	sum	0x54 0x43	0: Sensitivity not set 1: Sensitivity level 1 2: Sensitivity level 2 3: Sensitivity level 3
Active reporting of human presence information											
Human presence function	Active reporting of presence information	Report	0x53 0x59	0x80	0x01	0x00	0x01	0x00: Unoccupied 0x01: Occupied	sum	0x54 0x43	Report when there is a state change
	Active reporting of motion information	Report	0x53 0x59	0x80	0x02	0x00	0x01	0x00: None 0x01: Motionless 0x02: Active	sum	0x54 0x43	Report when there is a state change
	Active reporting of Body Movement Parameter	Report	0x53 0x59	0x80	0x03	0x00	0x01	1B Body Movement Parameter	sum	0x54 0x43	Report every 1 second. Value range: 0-100. (For more information on Body Movement Parameter, please refer to Chapter 8.4.)
	Time for entering no person state setting	Send	0x53 0x59	0x80	0x0A	0x00	0x01	None: 0x00 10s: 0x01 30s: 0x02 1min: 0x03	sum	0x54 0x43	The default setting is 30 seconds.

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
								2min: 0x04			
								5min: 0x05			
								10min: 0x06			
								30min: 0x07			
								60min: 0x08			
		Response	0x53 0x59	0x80	0x0A	0x00	0x01	None: 0x00 10s: 0x01 30s: 0x02 1min: 0x03 2min: 0x04 5min: 0x05 10min: 0x06 30min: 0x07 60min: 0x08	sum	0x54 0x43	For more information on "Time for entering no person state," please refer to Chapter 8.5 of this document.
	Active reporting of proximity	Report	0x53 0x59	0x80	0x0B	0x00	0x01	No state: 0x00 Near: 0x01 Far: 0x02	sum	0x54 0x43	00: No one/person stationary/chaotic movement 01: Approaching the sensor for 3 seconds continuously 02: Moving away from the sensor for 3 seconds continuously (For more information on proximity, please refer to Chapter 8.4 of this document.)
Information Inquiry											
Presence information inquiry		Send	0x53 0x59	0x80	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x81	0x00	0x01	0x00: Unoccupied 0x01: Occupied	sum	0x54 0x43	
Motion information inquiry		Send	0x53 0x59	0x80	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x82	0x00	0x01	0x00: None 0x01: Motionless 0x02: Active	sum	0x54 0x43	
Body Movement Parameter inquiry		Send	0x53 0x59	0x80	0x83	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x83	0x00	0x01	1B Body Movement Parameter	sum	0x54 0x43	

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
	Time for entering no person state inquiry	Send	0x53 0x59	0x80	0x8A	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x8A	0x00	0x01	None: 0x00 10s: 0x01 30s: 0x02 1min: 0x03 2min: 0x04 5min: 0x05 10min: 0x06 30min: 0x07 60min: 0x08	sum	0x54 0x43	
	Proximity inquiry	Send	0x53 0x59	0x80	0x8B	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x8B	0x00	0x01	No state: 0x00 Near: 0x01 Far: 0x02	sum	0x54 0x43	
UART Upgrade											
UART Upgrade	Start UART Upgrade	Send	0x53 0x59	0x03	0x01	0x00	0x01	4B Firmware package size + 15B Firmware version number	sum	0x54 0x43	Please refer to the tutorial on the Wiki for upgrade instructions.
		Response	0x53 0x59	0x03	0x01	0x00	0x01	4B Transfer upgrade package size per frame	sum	0x54 0x43	
	Upgrade package transmission	Send	0x53 0x59	0x03	0x02	0x00	0x01	4B Package offset address + len B Data Packages	sum	0x54 0x43	
		Response	0x53 0x59	0x03	0x02	0x00	0x01	0x01: Received successfully 0x02: Receive Failure	sum	0x54 0x43	
	Ending the UART Upgrade	Send	0x53 0x59	0x03	0x03	0x00	0x01	0x01: Firmware package delivery completed 0x02: Firmware package delivery not completed	sum	0x54 0x43	
		Response	0x53 0x59	0x03	0x03	0x00	0x01	0x0F	sum	0x54 0x43	

8.2 Scene mode

The function of scene mode is to **adjust the maximum detection range of the sensor to recognize human movements**. (Maximum detection distance of the sensor)

There are 4 modes for scene mode, with the default mode being the living room mode. The detection range values for each scene mode are as follows:

Scene Mode	Detection Radius (m)
Living room	4m - 4.5m
Bedroom	3.5m - 4m
Bathroom	2.5m - 3m
Area detection	3m - 3.5m

8.3 Sensitivity setting

The sensitivity setting adjusts the **detection distance of the sensor for human body in static state**.

There are 3 levels for sensitivity setting, with the default level being sensitivity 3. The detection range values for each sensitivity level are as follows:

Sensitivity	Detection Radius (m)
1	2.5 m
2	3 m
3	4 m

8.4 Additional information on Standard function

Function Point	Parameter Data Content	Function Description
Proximity report	Near/Far/No State	Near/Far/No State:

		During the target's movement, if it approaches the radar continuously for 3 seconds or moves away from the radar continuously for 3 seconds, the radar will report "approaching" or "moving away". When the target is in disordered movement or stationary state, the radar will report "none".
		Example: No state: No one present, person standing still, or person in random motion Near state: approaching the radar continuously for 3 seconds Far state: moving away from the radar continuously for 3 seconds
Body Movement Parameter report	Body Movement Parameter, range: 0-100	Body Movement Parameter: When there is no person in the space, the body movement parameter is 0. When there is a person present but stationary, the body movement parameter is 1. When there is a person present and in motion, the body movement parameter is 2-100 (the greater the amplitude/distance of the motion, the larger the body movement parameter).
		Example: When there is no one around: the activity parameter is 0 When someone is still: the activity parameter is 1 When someone is active: the activity parameter is 25

8.5 Time for entering no person state

The function of ime for entering no person state setting is to adjust the duration from "someone present" to "no one present" by selecting different absence trigger time settings.

There are 9 levels for the absence trigger time setting, with the default level being 30 seconds. The actual time interval from "someone present" to "no one present" is always greater than or equal to the current unmanned time setting.

9. Underlying Open function description

In older versions of millimeter wave sensors, there was no such thing as Underlying Open function. Underlying Open function is one level above Standard function, which means that this feature provides users with more data messages that can provide users with more customizable interfaces. If you do not want to use the results of the Standard function, you can enable the Underlying Open function and output the results of human presence and movement based on the data from this feature.

If you are a general user and feel that the results of the standard function already cover your use case, and the results obtained by the sensor in your environment are accurate enough, then you do not need to use the Underlying Open function.

9.1 List of Underlying Open function data information

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Underlying Open function information output switch										
Underlying Open function information output switch	Send	0x53 0x59	0x08	0x00	0x00	0x01	0x00: Turn off 0x01: Turn on	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x00	0x00	0x01	0x00: Turn off 0x01: Turn on	sum	0x54 0x43	This switch is defaulted to the closed state.
Underlying Open function information output switch inquiry	Send	0x53 0x59	0x08	0x80	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x80	0x00	0x01	0x00: Turn off 0x01: Turn on	sum	0x54 0x43	
Underlying Open function information										
Reporting of Sensor information	Report	0x53 0x59	0x08	0x01	0x00	0x05	**byte1**: Existence energy value Range: 0-250	sum	0x54 0x43	Existence energy value: There are electromagnetic waves in the environment, and the electromagnetic wave frequency changes less when there is no one around.

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
							byte2: Static distance Range: 0x01-0x06 **byte3**: Motion energy value Range: 0-250 **byte4**: Motion distance Range: 0x01-0x08 **byte5**: Motion speed Range: 0x01-0x14 (Please refer to chapter 9.2 for more information on the Underlying Open function.)			When there is a person in the space, the overall electromagnetic wave reflection will float weakly due to the slight movement caused by breathing (chest breathing). Stationary distance: The module detects the straight-line distance of human breathing, which is usually no more than 3 meters. Motion energy value: The amplitude value of motion causes different electromagnetic wave frequency changes. Motion distance: Detects the distance of the moving target. Motion speed: Real-time judgment of the speed of the moving target; the speed is positive (0x01-0x09) when approaching the radar and negative (0x0b-0x14) when moving away. When there is no motion speed, the value is 0a (0m/s), and the speed level progresses in 0.5m/s increments, such as 0x0b is 0+0.5m/s; 0x09 is 0-0.5m/s.
Existence energy value inquiry	Send	0x53 0x59	0x08	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x81	0x00	0x01	Range: 0~250	sum	0x54 0x43	
Motion energy value inquiry	Send	0x53 0x59	0x08	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x82	0x00	0x01	Range: 0~250	sum	0x54 0x43	
Static distance inquiry	Send	0x53 0x59	0x08	0x83	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x83	0x00	0x01	0x00: No one 0x01: 0.5m 0x02: 1m 0x03: 1.5m	sum	0x54 0x43	

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
							0x04: 2.0m			
							0x05: 2.5m			
							0x06: 3m			
Motion distance inquiry	Send	0x53 0x59	0x08	0x84	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x84	0x00	0x01	0x00: No one moving 0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m	sum	0x54 0x43	
Motion speed inquiry	Send	0x53 0x59	0x08	0x85	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x85	0x00	0x01	0x00: No one moving Range: 0x01~0x14	sum	0x54 0x43	
Approaching Moving away inquiry	Send	0x53 0x59	0x08	0x86	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x86	0x00	0x01	0x00: no 0x01:approaching 0x02:moving away	sum	0x54 0x43	00:Nobody/stationay/disorganized movement 01: Approach for 3s Radar 02: Continuous 3s Away from Radar
Moving parameters inquiry	Send	0x53 0x59	0x08	0x87	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x87	0x00	0x01	Range: 0-100	sum	0x54 0x43	

9.2 Underlying Open function information

Function Point	Parameter Data Content	Function Description
Reporting of human presence information.	1. Existence energy value (Statics noise of environment), range 0-250.	Existence energy value: a. Feedback of micro-motion noise value in the environment at all times. b. When there is no one in the space, the existence energy value is low and

	2. Static distance, range 0.5m-3m.	approximates the micro-motion noise in the environment. c. When there is a person standing still in the space (with micro-movements such as chest breathing), the existence energy value will fluctuate at a higher value. Static distance: The straight-line distance between the micro-motion area in the environment and the sensor. When there is a person standing still at a certain position in the space, the straight-line distance between that position and the radar will be output in real-time.
		Example: Without anyone present: Energy value is between 0-5, and the static distance is 0m. With someone present: Energy value is between 30-40, and the static distance is 2.5m.
Motion information report	1. Motion energy value (Motion noise of environment), range: 0-250 2. Motion distance, range: 0.5m-4m 3. Motion speed, range: -5m/s to 5m/s	Motion energy value: a. Can provide feedback on the constant motion noise in the environment. b. When there is no human present in the space, the motion energy value is low and approximates the constant motion noise in the environment. c. When there is human motion present, the motion energy value increases with the amplitude and proximity of the motion. Motion distance: The straight-line distance between the motion location in the environment and the sensor. When there is human motion present in the space, the straight-line distance between the human and the sensor is output in real-time.

		Motion speed:
		When there is motion present in the environment, a positive speed value is provided when the object is moving closer to the sensor and a negative speed value is provided when it is moving away. The target's motion speed is also determined in real-time.
		Example: Motion energy value: • 0-5 when no one is present • 15-25 for small movements at a distance by a person • 70-100 for large movements up close by a person Motion distance: • 3.5m when a person is continuously approaching a certain point Motion speed: • +0.5m/s when a person is continuously approaching a certain point.

10. Custom mode description

This instruction mainly focuses on detailed explanations and descriptions of the settings for underlying open parameter settings, and time logic settings in the sensor custom functions.

The parameter configurations of 10.1 to 10.3 are only effective in the custom mode.

10.1 List of Custom mode information

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Custom mode setting										
Custom mode setting	Send	0x53 0x59	0x05	0x09	0x00	0x01	0x01~0x04	sum	0x54 0x43	0x01: Custom mode 1. 0x02: Custom mode 2. 0x03: Custom mode 3. 0x04: Custom mode 4.
	Response	0x53 0x59	0x05	0x09	0x00	0x01	0x01~0x04	sum	0x54 0x43	
End of custom mode settings	Send	0x53 0x59	0x05	0x0A	0x00	0x01	0x0F	sum	0x54 0x43	Used to save custom parameters
	Response	0x53 0x59	0x05	0x0A	0x00	0x01	0x0F	sum	0x54 0x43	
Custom mode query	Send	0x53 0x59	0x05	0x89	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x05	0x89	0x00	0x01	0x01~0x04	sum	0x54 0x43	0x00: Custom mode is not enabled. 0x01: Custom mode 1. 0x02: Custom mode 2. 0x03: Custom mode 3. 0x04: Custom mode 4.
Underlying open parameter settings										
Existence judgment threshold settings	Send	0x53 0x59	0x08	0x08	0x00	0x01	Range: 0~250	sum	0x54 0x43	The electromagnetic wave threshold values for presence or absence of people in the environment are preset. Please refer to the default values. If there is interference from moving objects, collect the static spatial value and adjust accordingly.
	Response	0x53 0x59	0x08	0x08	0x00	0x01	Range: 0~250	sum	0x54 0x43	The default value is 33 (Please refer to chapter 10.2 for more information on the Underlying Open function parameters.)
Motion trigger threshold settings	Send	0x53 0x59	0x08	0x09	0x00	0x01	Range: 0~250	sum	0x54 0x43	Sensor trigger setting: the setting of motion amplitude when a person enters the environment, which is used to limit false alarms from the outside. Please use the default value as a priority.
	Response	0x53 0x59	0x08	0x09	0x00	0x01	Range: 0~250	sum	0x54 0x43	The default value is 4 (Please refer to chapter 10.2 for more information on the Underlying Open

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
										function parameters.)
Existence perception boundary settings	Send	0x53 0x59	0x08	0x0A	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	Detection range setting of the sensor, used to reduce false alarms of the radar and minimize interference outside the detection range.
	Response	0x53 0x59	0x08	0x0A	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	The default value is 5m (Please refer to chapter 10.2 for more information on the Underlying Open function parameters.)
Motion Trigger Boundary Setting	Send	0x53 0x59	0x08	0x0B	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	Setting the human activity detection distance is used to reduce radar false alarm rates and minimize interference from people walking outside the detection range of the door or glass doors.
	Response	0x53 0x59	0x08	0x0B	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	The default value is 5m (Please refer to chapter 10.2 for more information on the Underlying Open function parameters.)
Motion trigger time setting	Send	0x53 0x59	0x08	0x0C	0x00	0x04	Time information	sum	0x54 0x43	This is used for time accumulation of motion triggering to reduce false alarms through multiple judgments of triggering. It can be combined with motion amplitude trigger thresholds and motion trigger boundaries to limit performance.
	Response	0x53 0x59	0x08	0x0C	0x00	0x04	Time information	sum	0x54 0x43	Unit in ms, default 150ms (Please refer to chapter 10.3 for more information on the Underlying Open function parameters.)
Motion-to-Still Time setting	Send	0x53 0x59	0x08	0x0D	0x00	0x04	Time information	sum	0x54 0x43	This parameter is used to adjust the duration of reporting the current human motion state. In combination with the threshold settings for motion and stillness triggering, it can provide a rough indication of the degree of human motion in the environment.
	Response	0x53 0x59	0x08	0x0D	0x00	0x04	Time information	sum	0x54 0x43	Unit in ms, default 3000ms (Please refer to chapter 10.3 for more

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
										information on the Underlying Open function parameters.)
Time for entering no person state setting	Send	0x53 0x59	0x08	0x0E	0x00	0x04	Time information	sum	0x54 0x43	If the radar does not detect any breathing movements for a certain period of time, it will automatically enter a no-person state. This parameter is used to manually set the time for quickly entering the no-person state.
	Response	0x53 0x59	0x08	0x0E	0x00	0x04	Time information	sum	0x54 0x43	Unit in ms, default 30000ms (Please refer to chapter 10.3 for more information on the Underlying Open function parameters.)
Underlying open parameter inquiry										
Existence judgment threshold inquiry	Send	0x53 0x59	0x08	0x88	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x88	0x00	0x01	Range: 0~250	sum	0x54 0x43	
Motion trigger threshold inquiry	Send	0x53 0x59	0x08	0x89	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x89	0x00	0x01	Range: 0~250	sum	0x54 0x43	
Existence perception boundary inquiry	Send	0x53 0x59	0x08	0x8A	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x8A	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	
Motion Trigger Boundary inquiry	Send	0x53 0x59	0x08	0x8B	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x8B	0x00	0x01	0x01: 0.5m 0x02: 1m 0x03: 1.5m 0x04: 2.0m 0x05: 2.5m 0x06: 3m 0x07: 3.5m 0x08: 4m 0x09: 4.5m 0x0a: 5m	sum	0x54 0x43	
Motion trigger Time inquiry	Send	0x53 0x59	0x08	0x8C	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x8C	0x00	0x04	Time information	sum	0x54 0x43	

Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Motion-to-Still Time inquiry	Send	0x53 0x59	0x08	0x8D	0x00	0x01	0x0F	sum	0x54 0x43	
	Response	0x53 0x59	0x08	0x8D	0x00	0x01	Time information	sum	0x54 0x43	
Time for entering no person state inquiry	Send	0x53 0x59	0x08	0x8E	0x00	0x01	0x0F	sum	0x54 0x43	The Time for entering no person state in the low-level open parameters is different from that in the standard mode. In the low-level open parameters, this time value can be freely set to any value (not exceeding 1 hour), but in the standard mode, only specific values can be set.
	Response	0x53 0x59	0x08	0x8E	0x00	0x01	Time information	sum	0x54 0x43	

10.2 Underlying open parameter settings

Function Point	Parameter Data Content	Function Description
Existence judgment threshold settings	Existence judgment threshold, range from 0 to 250.	Existence judgment threshold: For distinguishing between the presence and absence of people based on the different energy levels in the environment, an appropriate threshold value can be set to form a simple discrimination criterion for determining the presence or absence of people.
		Example: When there is no one around: 0-5 When someone is present: 30-40 The existence judgment threshold is set to: 6-29 This can be used as a simple criterion for distinguishing between the presence and absence of people. (Threshold values can be adjusted based on actual judgment requirements to control the difficulty level of determining the presence or absence of people.)

Motion trigger threshold settings	Motion trigger threshold, range from 0 to 250.	Motion trigger threshold: By setting an appropriate threshold value based on the different motion energy levels in the environment when there is no one around, when someone is moving slightly, and when someone is moving significantly, a simple discrimination criterion for distinguishing between the active and still states can be formed. Example: When there is no one around: 0-5 When someone is still with slight body movements: 7-9 When someone is moving slightly at a distance: 15-20 When someone is moving significantly at close range: 60-80 The motion trigger threshold is set to: 10-14 This can serve as a simple criterion for distinguishing between active and still states. (Threshold values can be adjusted based on actual judgment requirements to control the level of difficulty in triggering motion detection.)
Existence perception boundary settings	Existence perception boundary, range from 0.5m to 5m.	Existence perception boundary: For the detection of stationary (slightly moving) targets in space, the radar can output its stationary distance in real-time. Therefore, by setting the existence perception boundary, the range of motion sensing can be controlled, which can in turn control the range of distinguishing between the presence and absence of people. Example: In the current environment: The real-time stationary distance of a stationary (slightly moving) target is

		3m (it is the source of slight movement interference). The existence perception boundary is set to <3m. The overall detection range of human presence can be reduced to less than 3m to exclude interference from non-human sources at 3m. (Set the threshold based on actual judgment to control the range of existence perception boundaries.)
Motion Trigger Boundary Setting	Range of motion detection boundary: 0.5m to 5m.	Motion triggering boundary: For detecting moving targets in the space, sensor can output real-time distance of the motion. Therefore, by setting the motion triggering boundary, the range of motion triggering can be controlled to determine the boundary between inactive (no person) and active (with person) states.
		Example: In the current environment: Real-time motion distance of a moving target: 3.5m (it is a motion interference source, such as a continuously rotating fan motor) Motion trigger boundary setting: ＜ 3.5m The overall range of motion detection can be reduced to less than 3.5m by setting the motion trigger boundary, which can exclude interference sources that are not human-made at 3.5m. (Thresholds can be set based on actual judgment to control the range of motion trigger boundaries.)

10.3 The setting for Time logic

Function Point	Parameter Data Content	Function Description
Motion trigger time setting	Motion trigger time, range: 0~1000ms.	Motion trigger time: To judge the active state, the following conditions must be met to be

		considered as an active state.
		a. The motion energy value is greater than the motion trigger threshold. b. Within the motion trigger boundary.
		c. Continuously meeting the threshold and boundary conditions within the set motion trigger time.
		With the participation of these three setting parameters, a relatively complete and detailed standard for judging the transition from stillness to activity is formed.
		Example:
		In the current environment:
		The target has been moving continuously for 1 second.
		Real-time spatial motion value: 30-40.
		Real-time motion distance: <2.5m.
		Motion trigger threshold setting: 15.
		Motion trigger boundary setting: 3m.
		Motion trigger time setting: 0.8s.
		At this moment, the target's motion energy value is greater than the set threshold, the motion distance is within the set boundary, and the target has been moving for more than the set time, so it can be judged as an active state.
		(Adjust the trigger time according to actual judgment to control the difficulty of motion triggering.)
Motion-to-Still Time setting	Motion-to-Still time, range 1~60s.	Motion-to-Still time:
		To determine the still state, the following conditions must be met:
		a. The motion energy value is less than the motion trigger threshold
		b. The above threshold condition is continuously satisfied within the set motion-to-still time
		These two setting parameters contribute to forming a more complete and

		detailed standard for determining the transition from active to still state.
		Example: In the current environment: Target has been stationary for 2 seconds Real-time motion value: 10 Motion trigger threshold setting: 15 Motion-to-still time setting: 1s At this moment, the motion energy value of the target is lower than the set threshold, and the duration of stillness exceeds the set time. Therefore, it can be judged as a still state. (Setting the time according to actual judgment to control the difficulty of maintaining stillness)
Time for entering no person state setting	The range for the time it takes to transition from a person-present state to a person-absent state is 0s to 3600s.	Enter unmanned state time: To determine the absence of people in the space, the following three conditions must be met to judge the unmanned state: a. The motion energy value is less than the motion trigger threshold b. There is an energy value less than the presence judgment threshold c. It is outside the presence judgment boundary d. Within the set time to enter the unmanned state, the above three conditions are continuously satisfied These four setting parameters work together to form a more complete and detailed standard for determining the unmanned state.
		Example: In the current environment: No person present Real-time motion energy value: 10 Real-time existence energy value: 2 Target movement distance: 4.5m

		Target stationary distance: 4m Existence judgment threshold setting: 40 Motion trigger threshold setting: 30 Motion trigger boundary: 3m Existence judgment boundary: 3m Time to enter unmanned state setting: 50s At this moment, the motion energy value, existence energy value, and dynamic and static distance all meet the conditions for judging unmanned state. After continuing for 50s, the system enters unmanned state. (The time setting for entering unmanned state can be adjusted according to actual needs to control the difficulty of entering unmanned state.)